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Draft Report: A Basic Classification System for Energy-Using Products -- Universal Device Classification

Bruce Nordman[1]

Hoi Y Cheung

Environmental Energy Technologies Division

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[1] Corresponding author: Bruce Nordman, BNordman@lbl.gov;
1 Cyclotron Road, Mailstop 90R2000, Berkeley, CA 94720 USA

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Summary

The number and types of devices in buildings that are connected to networks is continually increasing. This will make it possible for building owners to get information about energy use and other attributes automatically, at no additional cost. The technology to enable this, “Energy Reporting” is the ability of an individual device to report on its own power use, energy use, and power state to the network [Nordman, 2013a]. A number of protocols and data models exist or are being developed for this purpose, but a key problem is that none of them include a facility for a device to simply indicate what it “is." Examples of a device type could be refrigerator, light, computer, TV, or dishwasher. This paper proposes such a list of device types — perhaps the first — a Simple **U**niversal **D**evice **C**lassification System, which we abbreviate to UDC.

1. Introduction

The need for a simple classification system became clear during work on a standard data model for energy reporting, the Energy Management Working Group (EMAN)[1] of the Internet Engineering Task Force (IETF). That standard includes extensive data about device reporting — both fixed information (e.g. brand and model), as well as variable (e.g. location). The Working Group considered including an entry for basic device type, but no existing suitable classification system could be found to reference. All existing schemes are either:

- Domain-specific (e.g. for a subset of device types), or
- Highly complex (e.g. thousands or more entries)

Neither of these characteristics was suitable for the task of identifying devices that report energy use. What that called for was a system with two basic criteria:

- Simple: Not difficult for anyone to understand and use, and
- Universal: Covering every device in any building type anywhere.

Once a basic device categorization system has been developed, technology standards will be able to include the basic device type in their reporting.

Consider the manager of a large building, who receives reports on thousands of devices in the building that consume energy. With no automatic categorization or organization, the reporting will be of limited use. Information about a device such as brand/model could be used to guess or determine device type in an *ad hoc* way, but without standard categories the results will be inconsistent and time-consuming. When a device is manufactured, it is clear what it is, and that fact can be incorporated inherently in the device. This simple piece of data could be reported by every device,[2] and reported in a simple, standard way.

This draft report is submitted in partial fulfillment of Contract #41002 of the Northwest Energy Efficiency Alliance, "Energy Reporting and Standard Device Taxonomy." The goal of this task is to create a first draft of a simple, universal device classification system. This report examines the need for a standard device taxonomy, summarizes relevant existing organizational schemes, describes principles used to create the system, identifies candidate standards processes for incorporation of the taxonomy, and develops the classification system itself. The second chapter presents a survey of existing organizational schemes. The third chapter describes the elements considered in developing a basic list of device types, and Chapter 4 presents an initial proposal for a Simple Universal Device Classification System. Next steps and Conclusions are outlined in Chapter 5.

Origins

As above, this concept emerged in the context of the IETF/EMAN working group. The original proposal was phrased as “identity," and covered other aspects such as the brand and model of a device [Nordman, 2011a]. “Identity” turned out to have a great deal of pre-existing meaning to

[1] http://datatracker.ietf.org/wg/eman/

[2] This certainly only applies to devices that can communicate over a network or data link.

the group to whom it was presented (network technology professional), who specifically focused on individual identity (e.g. as a serial number) rather than group identity. The reaction to the term "identity" was so strong that it was necessary to return later (and to a different committee) with a different concept and term, simply “classification." Early discussions also used the analogy of “species” of device, since the Linnaeus taxonomy is a foundational example of categorization. While a relevant example, the species metaphor did not seem to be directly useful in describing devices.

Concept

The Simple Universal Device Classification (UDC) is a list of device types into which every device on the planet that uses or influences energy use can be categorized. Examples could be refrigerator, light, computer, television, vehicle, laundry appliance, etc. Devices should have their device type set by the manufacturer and incorporated in all devices before they arrive at place of use. Device type is not intended to be changeable by the customer. To illustrate the concept, the table below shows an example very simple classification system, which we call the “Minimal” list.

Table 1. Minimal Classification System

HVAC	*Lighting*	*Appliance*	*Electronics*	*Miscellaneous*
Heating	Lighting-fixed	Refrigerator	Computer	Kitchen
Cooling	Lighting-portable	Cooking-fixed	Display	Health-personal
Ventilation	Lighting-outside	Dishwasher	Printer	Pool-spa
Humidification	Lighting-other	Clotheswasher	AV-source	Outside
HVAC-control		Clothesdryer	AV-intermediate	Pump
HVAC-other		Water-Heater	Network-equipment	Motor
			Electronics-portable	Power
			Electronics-other	Infrastructure
				Business-equipment
				Vehicle
				Industrial
				Other

Notes: HVAC means space conditioning; Humidification includes dehumidification; HVAC–other includes mixed heat/cool; Lighting–fixed is hardwired; Lighting–portable has a normal plug; Appliance means a relatively fixed and larger device; Refrigerator includes freezers; Computer includes game console; Display includes TV; Printer includes all imaging equipment (MFD, copier, scanner, ...); Electronics–portable means operable with battery and not in above categories; Kitchen is devices not in Appliance category; Health-personal includes medical, hair dryer, etc.; Outside includes tools, lawn/garden; Power includes UPS, battery; Infrastructure includes timer, smoke detector, GFCI, ...; Business-equipment includes cash register, ATM, ...

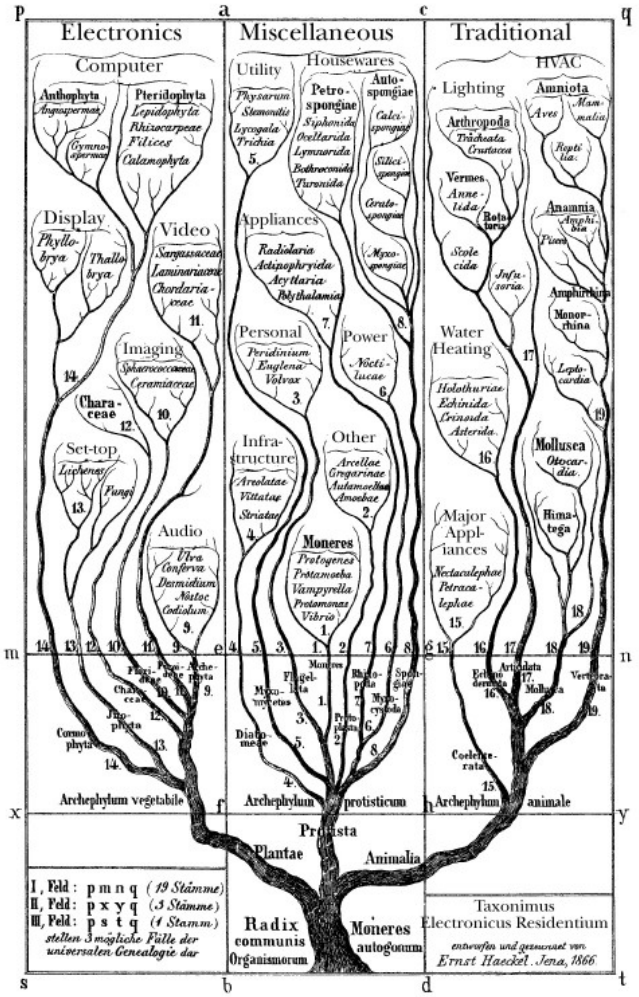
It is possible that this list is sufficient, though later we present a more lengthy list which we think is a better basis for discussion. The minimal list has 36 entries, and would have a

corresponding number for each entry, one through 36. Ideally the categories would be only for convenience, so that they would not have to be defined the same way by all users. However, the presence of "other" entries suggests the categories will need to have specific definitions. Considerations for this list were to:

- keep the number of entries very low,
- disaggregate more for end uses that consume more power (notably HVAC), and
- avoid distinctions based on size.

Note that in the listing, some devices are labeled by their specific identity (e.g. refrigerator) and some by the function they provide (e.g. heating). Heating can be done by a variety of different specific devices, such as a furnace or boiler, so is a grouping of types rather than a specific single type. While it would be ideal if the list was uniform in this respect (all identity or all activity), that is not possible. In this listing, each entry is a single word (sometimes with a hyphen).

The classification in the Minimal List is a very simple a taxonomy, but simpler. Taxonomy is "the practice and science of classification" [3]. The figure at the right (Nordman and Sanchez, 2006) shows that classification of energy-using devices is possible.



[3] http://en.wikipedia.org/wiki/Taxonomy_(general)

2. Survey of Existing Schemata

Many existing standards touch on topics related to basic device type, though most of these address a different specific purpose, cover only a subset of the devices in scope for this task, or both. Many of the systems described below informed the development of our initial basic device classification system. However, none provided an adequate direct or comprehensive basis for the list.

These organizing schemes have been drawn from a broad range of disciplines and sectors: building operation and energy, information technology, marketing and sales, lighting, trade, manufacturing, and construction. We reviewed these to be sure that there was no suitable existing system, to identify product types that might suggest additions to our list, and for terminology to possibly adopt.

Building Operation and Energy

Managing and analyzing energy consumption in buildings has spawned a variety of classification systems, both for research analytics and for dynamic operation. In general, these are created *ad hoc* for a particular study or research series.

Department of Energy

The Energy Information Administration (EIA) of the U.S. Department of Energy (DOE) tracks data about energy use, including end use consumption in buildings. A recent EIA report (EIA, 2011) assessed technologies that will influence changes in end-use energy in residential and commercial buildings. We took their list of devices but removed distinctions by building type and fuel type and came up with:

- Water Heaters
- Furnaces
- Hydronic Heating (Boilers)
- Room Air Conditioners
- Central Air Conditioners
- Heat Pumps
- Chillers
- Rooftop Air Conditioners
- Rooftop Heat Pumps
- Ground Source Heat Pumps
- Electric Resistance Heaters
- Refrigerator / Freezer
- Cooktops
- Clothes Washers
- Clothes Dryers
- Dishwashers

Another EIA publication, the Annual Energy Outlook (EIA, 2013) breaks down residential electricity use by:

- Space heating
- Space cooling
- Water heating
- Refrigeration
- Cooking
- Clothes dryers
- Freezers
- Lighting
- Clothes washers
- Dishwashers
- Televisions and related equipment
- Computers and related equipment
- Furnace fans and boiler circulation pumps
- Other uses

And commercial electricity as:

- Space heating
- Space cooling
- Water heating
- Ventilation
- Cooking
- Lighting
- Refrigeration
- Office equipment (PC)
- Office equipment (non-PC)
- Other uses

Note: Equipment related to televisions are set-top boxes and video game consoles. Equipment related to computers (desktop and laptop) includes monitors, printers, speakers, networking equipment, and uninterruptible power supplies.

These lists are sufficiently aggregate limited that they don't particularly inform our lists. Note that some entries are specific identity and some identify function.

Electronics and Miscellaneous

In 2006 a taxonomy was developed primarily for product types in the Miscellaneous and Electronics end uses (Nordman and Sanchez, 2006). The taxonomy has three end uses — Electronics, Miscellaneous, and Traditional. Each end use consists of multiple product categories (e.g. Audio and Computer under the Electronics end use), which contains individual product types (e.g. Amplifier and Audio Mini-system under the Audio product category). Meier et al. (2008) developed an expanded list of Electronics and Miscellaneous devices contained in Appendix B.

The 2006 taxonomy has been referenced by researchers in Europe, the IEA-4E process on Mapping and Benchmarking for efficiency policy, other LBNL projects, and elsewhere. Since the Nordman and Sanchez (2006), and Meier et al. (2008) taxonomy is more detailed and has more sub-product types than we need in our basic device list, we distilled the Electronics and Miscellaneous end uses by extracting the representative product types, and inserted in our draft taxonomy.

CEA 2045 (USNAP)

The USNAP standard was developed to provide a physical-layer neutral method (the Modular Communications Interface, MCI) of connecting appliances to networks for demand response and related purposes. It was standardized through the American National Standards Institute (ANSI) by way of the Consumer Electronics Association (CEA) and became ANSI/CEA 2045. The USNAP Alliance (usnap.org) continues to promote the standard. Devices are called Smart Grid Devices (SGD) receive signals from the grid. SGD device types are as follows:

- Unspecified Type
- Water Heater - Gas
- Water Heater - Electric
- Water Heater – Heat Pump
- Central AC – Heat Pump
- Central AC – Fossil Fuel Heat
- Central AC – Resistance Heat
- Central AC (only)
- Evaporative Cooler
- Baseboard Electric Heat
- Window AC
- Portable Electric Heater
- Clothes Washer
- Clothes Dryer - Gas
- Clothes Dryer - Electric
- Refrigerator/Freezer
- Freezer
- Dishwasher
- Microwave Oven
- Oven – Electric
- Oven – Gas All others
- Cook Top – Electric
- Cook Top - Gas
- Stove – Electric

Stove - Gas
Dehumidifier
Fan
Pool Pump – Single Speed
Pool Pump – Variable Speed
Electric Hot Tub
Irrigation Pump
Electric Vehicle
Hybrid Vehicle
Electric Vehicle Supply
Equipment – general (SAE J1772)
Electric Vehicle Supply Equipment – Level 1
Electric Vehicle Supply Equipment – Level 2
Electric Vehicle Supply Equipment – Level 3
In Premises Display
Energy Manager
Gateway Device
Manufacturer Defined Device Types

The coverage of CEA 2045 is limited to devices that it anticipates could interact with the grid, notably HVAC systems, major appliances, pumps, and vehicles. CEA 2045 also references an energy information display, and control and communications devices. It distinguishes some items by fuel type, speed, or capacity.

Project Haystack

Project Haystack is "an open source initiative to develop tagging conventions and taxonomies for building equipment and operational data. We define standardized data models for sites, equipment, and points related to energy, HVAC, lighting, and other environmental systems."[4]
Project Haystack covers:

Networks: devices, networks, and protocol connections
Energy: electricity and flow metering
AHUs: air handler units and rooftop units
VAVs: variable air volume and HVAC zones
Chillers: chillers and chiller plants
Boilers: boilers and boiler plants
ElecPanels: electric panels and circuits
Lighting: lighting systems

Despite its goal, Project Haystack does not appear to include a clear taxonomy of devices in buildings.

Zigbee

ZigBee refers to two distinct sets of standards:

- a mechanism to transfer data wirelessly among a set of local devices using the IEEE 802.15.4 standards;
- a collection of application layer protocols, which can be transmitted over 802.15.4, or over any other suitable physical layer.

We are concerned only with the second group, in particular, that component of the latter called Smart Energy Profile (SEP) version 2.0 (Zigbee, 2013). SEP 2.0 includes a “Device Class” as follows.

[4] http://project-haystack.org/

Programmable Communicating Thermostat	Simple misc. (Residential On/Off) loads
Strip Heaters	Exterior Lighting
Baseboard Heaters	Interior Lighting
Water Heater	Electric Vehicle
Pool Pump	Generation Systems
Sauna	Load Control Switch
Hottub	Smart Inverter
Smart Appliance	EVSE
Irrigation Pump	RESU
Managed Commercial and Industrial (C&I) Loads	Energy Management System

Note: EVSE is Electric Vehicle Supply Unit.

As with ANSI/CEA-2045, this has a limited set of devices, mostly those intended for interaction with the utility grid.

Information Technology

Various standards bodies who are focused on information technology products have needed to enumerate device types. Several of these are described below. In general, these are anecdotal and *ad hoc* in nature.

Distributed Management Task Force (DMTF)

The DMTF defines a set of entity types in its Common Information Model (CIM). These cover components of devices rather than the entire device. (Note that components are out of scope of this task.) The core purpose of the DMTF is to manage computers, so the listing below is for the ComputerSystem type. Some of these are clearly not computers at all (e.g. printers or network equipment). In addition, the DMTF specifies that the enumeration is for the function of the device rather than the device itself. For example, a "web caching" server is just a server before it arrives at its place of use. The DMTF expands the list on an as-needed basis. This list has been reordered and the categorization added (original has no categories).

Miscellaneous	Web Caching	Virtual Library System
UPS	Management	Management Controller
Not Dedicated	Block Server	Host-based RAID controller
Unknown	File Server	Storage Device Enclosure
Other	Storage	
DMTF Reserved	Storage Virtualizer	*Network*
Vendor Reserved	Media Library	Switch
	ExtenderNode	Layer 3 Switch
Data Center	NAS Head	Central Office Switch
Access Server	Self-contained NAS	Hub
I/O	Virtual Tape Library	Firewall

Repeater	Ethernet Switch	IP Phone
Bridge/Extender		Desktop
Gateway	*Office*	Laptop
Chassis Manager	Print	Network PC/Thin Client
FC Switch	Mobile User Device	

For IT devices, this list is much too detailed. Most other devices missing.

Universal Plug-and-Play

The Universal Plug and Play (UPnP) protocol is designed to enable devices to self-configure their interaction and avoid complicated set-up procedures before devices can work together. Device types have been added to UPnP on an ad hoc basis. As of November, 2013, the following are listed (UPnP, 2013).

Category	**Includes**
Audio/Video	MediaServer and MediaRenderer
Basic	Basic Device
Home Automation	SolarProtectionBlind
	Digital Security Camera
	HVAC
	Lighting Controls
Networking	Internet Gateway
	WLAN Access Point
Printer	Printer Enhanced
	Printer Basic
Scanner	Scanner
Sensor Management	SensorManagement
Telephony	Telephony

As this list is limited and not created with a general categorization in mind, it does not specifically inform the UDC.

Marketing and Sales

Several popular online marketplaces — including Amazon and Google — have created taxonomy and product lists to organize products that other companies offer for sale. Energy Star also organizes products to provide information for the purchase process. These are all relevant to the UDC since the organization and naming needs to make sense to ordinary people.

Amazon Product Selling Categories

Amazon lists approximately 30 product categories, which a seller can use to describe their product in a uniform, consistent way (Amazon, 2013a; Amazon, 2013b). The product categories

and the product types that fall under them contain both energy-using and non-energy-using devices. The most relevant energy-using product categories are as follows.

- Amazon Kindle
- Camera & phone
- Cell phones
- Consumer electronics
- Electronics Accessories (e.g. Audio, video, camera, etc.)
- Home & Garden (e.g. kitchen, home appliances)
- Health and personal care
- Office products (e.g. printers, calculators)
- Personal computers
- Tools and home improvements (e.g. hand and power tools, electrical)
- Video games & video game consoles
- Industrial & scientific (e.g. lab equipment, power transmission)

Amazon product categories group many dissimilar product types in the same category. These broad categories did not contribute to the UDC in a useful way. For example, Amazon groups furniture, printers, and calculators under Office Products, while Tools & Home Improvements includes hand and power tools and building materials. The Amazon list did serve as a guide to expand the descriptions for a few product entries in the UDC. The product categories (Amazon Services 2013) and site directory (Amazon 2013) largely refer to the same Amazon product directory, but the site directory lists more product sub-types.

Google Merchant Center

Google Merchant Center is a tool that uploads product listings to be used for Google Shopping, Product Listing Ads, and Google Commerce Search (Google, 2013). The Merchant Center maintains a taxonomy to categorize products in Google's search results. Use of the taxonomy is mandatory for certain countries and product categories, and recommended but not required for others. Google indicates that the taxonomy is updated every three months; the November 2013 version (Google 2013) contains over 5,700 entries. Google calls the highest levels of the taxonomy "the verticals," which refer to broad categories of products. Product subcategories of the verticals are more specific, and each layer breaks the vertical into a smaller product family. For example:

Electronics > Audio > Audio Players & Recorders > MP3 Players.

It is uncommon, but some entries have up to seven levels.

The Google taxonomy is quite extensive and spans product categories from electronics to gardening tools to grocery items. It contains 21 verticals, and the vertical most relevant for our purpose is Electronics, while other verticals such as Arts & Entertainment, Hardware, and Software consist mostly of items that do not usually or ever use energy. Listed below are the taxonomy levels under Electronics that are most relevant to energy-using devices.

- Arcade Equipment
- Audio
- Communications
- Computers
- Networking
- Plug & Play TV Games
- Print, Copy, Scan & Fax
- Video
- Video Game Console

EPA Energy Star

Created in 1992 by the Environmental Protection Agency (EPA), ENERGY STAR now provides certification for more than 65 products, grouped under the categories listed below. Energy Star intends to influence how manufacturers design products and which products people purchase, so it is organized around products at point of sale.

Appliances	Building Products	Battery Charger
Electronics	Commercial Food Service	Lighting & Fans
Heating & Cooling	Eqt.	Other
Water Heaters	Office Equipment	

The Energy Star product types well correspond to the entries in the UDC.

Lighting

Few product listings disaggregate lighting to any significant degree. To explore lighting in more detail, we looked at three associations serving the lighting industry to seek out any established taxonomies we could use as guides and checks. However, we were unable to locate any lighting taxonomies, instead we strengthened the lighting product list based on content gleaned during our investigations.

The American Lighting Association (ALA) is a trade association representing the residential lighting industry in the U.S. and Canada, with objectives organized into tgovernment affairs, advertising/consumer awareness, and education. The ALA website offers fundamental lighting information on lighting types, fixtures, and selection, rather than focusing on the energy-using aspect of lighting.

The Illuminating Engineering Society of North America (IES) is a technical society for lighting and illumination. The objective is to “communicate information on all aspects of good lighting practice," and IES publishes the widely used “IES Lighting Handbook." We were unable to find a taxonomy or lighting product list on the IES website.

The National Electrical Manufacturers Association (NEMA) has members includiing electrical equipment and medical imaging manufacturers. Its 400-plus member companies manufacture products used in the generation, transmission, distribution, and end use of electricity, as well as medical diagnostic imaging. “Lighting systems” is one of NEMA’s ten member product divisions, and we were unable to find an established taxonomy for lighting.

Trade and Manufacturing

Many trade associations categorize the types of products produced by their member companies, and other organizations have codings for products and classifications for types of industrial facilities.

American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) is a building technology society, with industry members focused on building systems, energy efficiency, indoor air quality, refrigeration, and sustainability. We closest item we found to a taxonomy is the "ASHRAE Product & Service Directory" (ASHRAE 2013), listing approximately 75 product and services. Many entries in the directory are services rather than products (e.g. "water treatment", "energy recovery"), and even listed products were too general for our purpose (e.g. "tools", "valves").

Association of Home Appliance Manufacturers (AHAM)

The Association of Home Appliance Manufacturers (AHAM) is the trade association of the home appliance manufacturing industry in the US and Canada. Its members include the manufacturers of major, portable, and floor-care home appliances and the companies who supply and service these manufacturers. AHAM does not have an established taxonomy, but we were able to extract product types under their home appliance divisions (i.e. major, portable, floor care) (AHAM, 2013). Among the three divisions, the major appliance division is the most relevant to the UDC; its product categories are listed below:

- Clothes Washers
- Clothes Dryers
- Cooking Ventilation Equipment
- Dehumidifiers
- Dishwashers
- Food Waste Disposers
- Freezers
- Ice Machines
- Microwave Ovens
- Ranges and Ovens
- Refrigerators
- Room Air Conditioners
- Trash Compactors
- Wine Coolers
- Warming Drawers

Universal Product Code (UPC)

The Universal Product Code (UPC) is a barcode system widely used in many countries for labeling and tracking retail products. The most common form - the UPC-A - consists of 12 numerical digits, which are uniquely assigned to each trade item. Variations of the code include UPC-E, the European Article Number (EAN) -13, and EAN-8. The UPC is maintained by GS1, a non-profit organization that develops standards for the supply and demand chains sector. We contacted GS1 to check if they have a product taxonomy, and they indicated that they leverage the UNSPSC but do not have a product list of their own.

Standard Industrial Classifications

Our economy and society developed early measurement and organizational systems to track material and product manufacture. Between 1938 and 1940, the US Central Statistical Board created Standard Industrial Classifications (SIC) to standardize the classification of industrial data.

The Standard Industrial Classification (SIC), established in 1937, is a system used by government agencies for classifying industries by four-digit codes, ranging from 0100 to 9995. The first 2 digits indicate the major industry group, while the first 3 digits altogether indicate the industry sub-group. For example, industry groups related to agriculture, forestry, and fishing include:

Major Group 01: Agricultural Production Crops
Major Group 02: Agricultural production livestock and animal specialties
Major Group 07: Agricultural services
Major Group 08: Forestry
Major Group 09: Fishing, hunting, and trapping

Then "Industry Group 011: Cash Grains" has the following entries:

0111 Wheat
0112 Rice
0115 Corn
0116 Soybeans
0119 Cash Grains, Not Elsewhere Classified

In the U.S., the SIC code is being replaced by the six-digit North American Industry Classification System (NAICS code) released in 1997, although some government agencies continue to use the SIC code. The update from the SIC to NAICS code was intended to reflect changing economic conditions and to provide more flexibility in handling emerging industries.

We reviewed both the SIC and NAICS codes, and they cover a range of products, services, and administrative divisions. For the SIC, energy-using products "under 3577 - Computer Peripheral Equipment, Not Elsewhere Classified" are the most relevant for our purpose, but they were already included in our draft taxonomy. In general, these classification systems did not particularly inform the UDC.

United Nations Standard Products and Services Code (UNSPSC)

The United Nations publishes a Standard Products and Services Code (UNSPSC), for use in facilitating electronic commerce. The UNSPSC has a five-level hierarchy coded as an 8-digit number; each level contains a two-character numeric value and a textual description, such as the following:

- Segment 44000000 Office Equipment and Accessories and Supplies
    - Family 44100000 Office machines and their supplies and accessories
        - Class 44101500 Duplicating machines
            - Commodity 44101501 Photocopiers
                - Business Function (the function performed by an organization in support of the commodity

For this project, we reviewed version 15.1101 of the UNSPSC codeset, published in January 25, 2013, which is the most updated version we could find on the UNSPSC website (UNSPSC 2013). The codeset includes 1,500 pages of entries, with approximately 30 commodity entries

per page. It is the longest and most wide-reaching taxonomy we reviewed for this project. Although the UNSPSC does not cover, for example, electronic sub-categories as detailed as Nordman and Sanchez (2006), its entries cover many sectors of the economy from thousands of raw materials and products (e.g. plants, fruits, chemicals, garments), to very detailed services and processes (e.g. in mining, manufacturing, and other sectors).

We did not have any new entries to add to our draft taxonomy from the UNSPSC, however, since entries in the draft taxonomy are quite high-level, and already includes the more detailed descriptions found in the UNSPSC. For example, a "laminator" and "check writing machine" in the UNSPSC are already incorporated under "business equipment" in the UDC. Many entries such as "airport and railway signaling systems" are far too detailed for the UDC.

Construction

The design and construction industries have long sought to organize and automate their activities to promote efficiency and quality. Several systems in the U.S. are vying for dominance in this area. The most prominent of these are described below. It is likely that significant similar systems exist elsewhere in the world. While some of these specify that they are to be applied to building operation (and maintenance), they all originate and are dominated by the design and construction aspect of buildings.

MasterSpec

MasterSpec is a master guide building and construction specification system, widely used in the design and construction industry by architects, engineers, and other design professionals. It is published by the Architectural Computer Services for the American Institute of Architects (AIA and ARCOM, 2013). MasterSpec consists of thousands of specifications under different category divisions and packaged in practice-specific libraries such as the following specifications: Architectural, Engineering, Mechanical, Fire Protection, and Electrical. Most MasterSpec entries are not energy-using devices.

ASHRAE committee SPC 201P is developing the Facility Smart Grid Information Model (FSGIM) to address a Smart Grid Priority Action Plan need. They have selected MasterSpec as a way to classify products.

Industry Foundation Classes (IFC)

The Industry Foundation Classes is a data model (and XML format) for entities used in the design and construction industries. IFC covers many details well outside the device classification scope, but does include a number of enumerations of device types that are relevant (IAI, 2013). IFC4[5] contains over 1,000 total entries, including 242 categories and

[5] A key file with all entries is: IFC4/annex/annex-c/inheritance_tree_IfcObject.htm

subcategories. The enumerations are grouped into several “domains," including HVAC and Electrical.

The table below omits irrelevant entries from the the HvacDomain list. The category names have been abbreviated for clarity.

UnitaryEquipment
Airhandler
Airconditioningunit
Dehumidifier
Splitsystem
Rooftopunit

HvacDomain
Boiler
Burner
Chiller
Coil
Condenser
CooledBeam
CoolingTower
ElectricGenerator
ElectricMotor
Engine
EvaporativeCooler
Evaporator
HeatExchanger
Humidifier

Communications
Antenna
Computer
Fax
Gateway
Modem
Networkappliance
Networkbridge
Networkhub
Printer
Repeater
Router
Scanner

AudioVisualAppliance
Amplifier
Camera
Display
Microphone
Player
Projector
Receiver
Speaker
Switcher
Telephone
Tuner

ElectricAppliance
Dishwasher
Electriccooker
Freestandingelectricheater
Freestandingfan
Freestandingwaterheater
Freestandingwatercooler
Freezer
Fridge_Freezer
Handdryer
Kitchenmachine
Microwave
Photocopier
Refrigerator
Tumbledryer
Vendingmachine
Washingmachine

LightFixture
Pointsource
Directionsource
Securitylighting

ElectricFlowStorage
Battery
Capacitorbank
Harmonicfilter
Inductorbank
UPS

TransportElement
Elevator
Escalator
Movingwalkway
Craneway
Liftinggear

Note that printer and copier are in different categories. This is presumably as copiers historically didn’t communicate with other devices, but ignores the fundamental activity that copiers are engaging in (duplicating information). Clearly categorization can be done with different schemes in mind.

Each enumeration includes (not listed here) a “USERDEFINED” and a “NOTDEFINED” entry. In the standard, entries are listed as all capitals. They have been converted to titlecase here for readability. Many of the definitions include the phrase “have the primary function of”.

Several product types are named “FreeStanding”.

IFC includes plumbing elements (“IfcSanitaryTerminalTypeEnum”), which are traditionally not powered, but increasingly are. It includes types of electrical and electronic outlets (“IfcOutletTypeEnum”) that traditionally do not consume power (GFCI outlets an exception) but are certainly involved in electricity distribution. It includes lighting technology type (e.g. Fluorescent, Halogen, LED), a distinction we do not anticipate making. It has categories for switching devices, time controls, electricity distribution components, many HVAC elements (e.g. dampers),

OmniClass

The OmniClass specification (OCCS, 2013) was originally developed for the design and construction industry, but has recently gained traction as a classification system for building operation, such as its emerging reference with in the Oasis-OBix system[6]. We present details on OmniClass here to critically examine whether OmniClass could be a basis for the UDC. OmniClass is divided into parts, one of which (Table 23) is on Products. The categories within Table 23 (“Level 1 categories”) are shown below. Many of the individual entries are not energy-using devices. The table has examples of what is included in each of these categories; red text has been added to list energy-using devices not obvious from the OmniClass notes.

Category	Description	Notes (red text added)
11: Site Products	Products used on the project grounds and site.	Includes bricks, blocks, basic materials, concrete mixtures, landscaping and horticulture products, planting equipment, ground anchorages, ground improvement products, sheeting and revetments, retention structures. Also includes temporary site products. Also: Parking meters and kiosks, access control, gates, mowers, exterior signs.
13: Structural and Exterior Enclosure Products	Products used to provide the facility’s structure or to enclose the facility or provide protection from the elements.	Includes exterior finishes, foundations, structural concrete products, envelop enclosure products, structural framing products, roofing products, and thermal and moisture protection. Also: Exterior doors.
15: Interior and Finish Products	Products used inside the facility to finish surfaces and divide spaces.	Includes interior finishes such as paints ceilings, and flooring, and interior space division materials such as a gypsum board and other partitions.
17: Openings, Passages, and Protection Products	Products which allow for access within a facility or between a facility and the outside.	Includes products such as doors, windows, frames, fire doors, hatches, louvers, and awnings, shutters, and other protection of openings. Also: Door hardware, access control.
19: Specialty Products	Architectural and other accessories and ornamentation used on the exterior and	Includes steeples, spires, lockers, fireplaces, stoves, flagpoles, scales, specialty bathroom products, and engineered structures. Also: Displays, signs, pest repellants.

[6] OASIS Open Building Information Exchange (oBIX), www.oasis-open.org/committees/tc_home.php?wg_abbrev=obix

	interior of the facility, and other miscellaneous products.	
21: Furnishings, Fixtures and Equipment Products	Amenities and other products that enable the use and enjoyment of the facility, both interior and exterior.	Includes recreational and fitness equipment, art, playground equipment, pools, potted plants, furniture, and food service and other light duty equipment. Does not include industrial equipment. Also: Retail eqt., kitchen eqt., theater eqt., arcade mach., vending mach., ticket mach., money handling eqt., agricultural eqt., laundry eqt., bathroom eqt., cleaning eqt., musical instruments.
23: Conveying Systems and Material Handling Products	Products that comprise systems to transport people or materials.	Includes elevator equipment, dumbwaiters, lifts, conveyors, hoists, and cranes.
25: Medical and Laboratory Equipment	Products used specifically in medical and laboratory applications.	Includes dental equipment, radiology equipment, operating room equipment, and microscopes.
27: General Facility Services Products	Facility Service products that have uses in multiple disciplines.	Includes piping, pumps, motors, and integrated control systems. Also: Sensors, bldg. automation, air filters, recycling eqt.
29: Facility and Occupant Protection Products	Products intended to protect both the occupant and facility from harm.	Includes environmental detectors, spill kits, fire safety items, sprinklers, defibrillators, detectors, alarms, and access control. See also Information and Communication Specific Products and Equipment. Also: Security devices.
31: Plumbing Specific Products and Equipment	Products specifically related to plumbing.	Includes toilets, sinks, faucets, drains, and plumbing fixtures and equipment. See General Facility Services Products for pipes, hangers, and pumps. Also: Water heaters, drinking fountains.
33: HVAC Specific Products and Equipment	Products specifically related to HVAC.	Includes complete cooling and heating systems, heat pumps, air handling units, air ductwork, and HVAC instrumentation and control devices. See General Facility Services Products for pipes, hangers, and pumps.
35: Electrical and Lighting Specific Products and Equipment	Products specifically related to electricity and lighting.	Includes power transformers, filters, conditioners, luminaries, lighting, switches, and electrical and lighting control devices. See General Facility Services Products for conduits and wires.
37: Information and Communication Specific Products and Equipment	Products which aid in the collection & exchange of related data between one or more entities.	Includes speakers, microphones, video monitors, audio/visual products, and IT equipment. See General Facility Services Products for conduits and wires.
39: Utility and Transportation Products	Products used for providing utility services and products specific to transportation applications.	Includes water treatment equipment, water flow controls, floating docks, culverts, large pipes, and roadway monitor and control equipment. See Site Products for pavement. Also: Cameras, railway / aviation / port eqt., solid waste eqt.

The OmniClass system shows how difficult and often seemingly arbitrary the categorization can be. For example, “Ventilation for cooking” is in “Furnishings, Fixtures and Equipment Products” and not with other HVAC devices. Equipment for Recycling is in “General Facility Services Products” but solid waste equipment is in “Utility and Transportation Products”.

Since HVAC classification has been difficult, the HVAC section of OmniClass (23-33) is shown below. Note that some entries, e.g. ductwork, are not energy-consuming devices.

HVAC Category	Description
HVAC Specific Products and Equipment	Products specifically related to HVAC. Includes complete cooling and heating systems, heat pumps, air handling units, air ductwork, and HVAC instrumentation and control devices. See “General Facility Services Products” for pipes, hangers, and pumps.
Commercial Boilers	a closed vessel in which water or other fluid is heated on a commercial scale
Furnaces	is a device used for heating.
HVAC Heating Units	any device or system for heating a building.
Heat Pumps	a device that moves heat from one location (the 'source') to another location (the 'sink' or 'heat sink') using mechanical work.
Cooling and Freeze Components	Components used in the cooling and freezing cycle.
Chillers	is a product that removes heat from a liquid via a vapor-compression or absorption refrigeration cycle.
Cooling Towers	heat removal devices used to extract waste heat to the atmosphere.
Air Handling Units	is a device used to condition and circulate air as part of an HVAC system.
Air Humidity Control Equipment	Equipment used in the control of humidity.
HVAC Dampers	Devices deadens, restrains, or depresses in HVAC.
Air Circulators	Products used for the movement of air in a circulator or circuit.
HVAC Fan Coil Units	Devices consisting of a heating or cooling coil and a fan and controls the temperature of air in a space.
HVAC Coils	a series of loops specific to HVAC.
Refrigerant Condensing Units	Vapor condensers in a refrigeration system, where the refrigerant is liquefied and discharges its heat to the environment.
Air Conditioning Equipment	Equipment used for air conditioning purposes.
HVAC Air Terminals	Units at the end of a branch duct through which air is transferred or delivered to the conditioned space.
HVAC Condenser Units	Unit specific to HVAC which condenses air.
HVAC Coolers	Devices specific to HVAC used to cool the air.
Air Dryers	A compressed air dryer is a product for removing water vapor from compressed air.
HVAC Ductwork	The system of ducts in a particular building used for HVAC.
HVAC Specialized Equipment	Specialized equipment for HVAC.
Solar Water Heating Equipment	Equipment used to heat water through solar power.
Energy HVAC Recovery Equipment	Equipment used to recover HVAC energy.

This is the best HVAC taxonomy we found.

Summary

No existing categorization scheme matches or meets our purposes, though many have useful insights. Most systems are either too limited, too complicated, or have an uneven level of detail.

3. Considerations in Developing the UDC

The sources above provide a variety of insights about our classification system, potential future modifications or extensions, and alternative classifications proposed by others. This chapter extends the review described above, raises issues that need to be considered in developing the UDC, explains decisions we have made, and highlights some outstanding questions. Sections cover what types of devices are in scope of the list, how device type is determined, how many entries the list should have, whether devices should report names or numbers, how to name and describe entries, the structure of the list, language issues, and list granularity.

Scope

The scope of the UDC is entire "devices", entities with power cords or mains power connections[7]. The UDC does not address internal components. Classification is based on the primary function of the device; a device may have other functions (and many do, e.g. a furnace can include a fan). Usually the primary function uses the most energy, but there are exceptions. For example, most of the energy used by a garage door opener results from simply listening for a signal; the light that comes on when the door starts moving uses the next-largest portion of the total energy; and the least energy is spent actually opening and closing the door.

Setting the classification

Classification is determined by each individual device, set at the time of manufacture, and never changes.

Number of entries

A key question is how many entries the UDC should have. An example system is the ASCII character set encoding. With seven bits, the basic ASCII set has 128 entries, with 95 of them being printable characters. ASCII specifies a single simple and compact numeric correspondence for letters, numbers, and symbols. It makes no attempt to cover characteristics other than the character's identity such as font, size, etc. Because of its simplicity, it can be utilized universally, or nearly so. ASCII has been extended over time, but its core has remained stable.

After considerable development in computing technology, it became necessary to develop a much more comprehensive system of encoding characters. The Unicode system was first published 28 years after the first version of ASCII. Unicode has thousands of entries, but the original ASCII is a subset of Unicode.

[7] Eventually products powered by low-voltage DC (e.g. USB) will need to be included. Most such devices today are best seen as components of a primary device (e.g. a keyboard on a computer) but that is beginning to change.

Another reference point is "Dunbar's Number". Per Wikipedia[8],

> "Dunbar's number is a suggested cognitive limit to the number of people with whom one can maintain stable social relationships. … It has been proposed to lie between 100 and 230, with a commonly used value of 150."

Since ordinary human beings are the primary consumer of the classification system, a key criterion is that people will be able to remember entries and discern among them. Thus, Dunbar's number provides a sense of the maximum size that the list should be, though it should not be seen as a minimum.

Intuitively, a list of ten device types would necessarily have very broad groupings and so seems too few. A thousand entries would have to make fine distinctions that most users would be unlikely to remember or understand. The "right" answer then seems to be on the order of two orders of magnitude, consistent with Dunbar's number, and ASCII. As with ASCII, as long as there are no more than 255 entries, then a single byte of data could be used. If the count ends up close to or more than that, then two bytes would definitely suffice.

Reporting names or numbers

An enumeration (0, 1, 2, 3, …) has several advantages over a name (e.g. "refrigerator", "computer", "television"): it is smaller to store and transmit; it can be converted to a name in whatever language is desired; and it is less susceptible to unintended variations or ambiguities. Encoding a structure in the numeric values is possible but probably not desirable. One can always have a table that maps entries to categories; having this external to the enumeration means that the mapping can change or be different in different applications. Also, adding encoding of category information adds complexity and likely limits. Thus, the list should be a single enumeration with no implied significance to the ordering.

Structure

With a simple numerical enumeration, it is not necessary to have any structure at all. That said, groupings can be created for subsets of the list, or even have levels of structure with groups inside of groups. The Linnaeus taxonomy of living beings has a seven level structure. The Nordman/Sanchez taxonomy of Electronics and Miscellaneous devices has a three-level structure (end use, category, and device). The Google Merchant Center structure can have up to seven levels.

Ideally the UDC would not have a formal structure of categories and individual entries, any more than the ASCII encoding does. That said, entries do fall into obvious groupings that people can and will apply. In addition, the presence of entries labeled "- other" likely make it necessary to be define categories to know what should be in each of these. It is sensible to group items numerically that are related to each other, as is done in ASCII, but ultimately the numbers

[8] http://en.wikipedia.org/wiki/Dunbar%27s_number - accessed November 4, 2013.

themselves have no inherent meaning (so that an entry can be added to the end of the list and be included in any of the categories).

Naming

While a device will report just its classification numerical entry, for practicality it is necessary to have short names for use by both ordinary people and for convenience in technical discussions and documents. In the Electronics and Miscellaneous Taxonomy (Nordman and Sanchez, 2006), the great majority of entries had a name of three words or less. The principles used for naming in that report were as follows:

> We brought a variety of principles to the process of selecting names for product types.
>
> - Strive for brevity, e.g. dropping "electric" from "electric knife" since non-powered knives would obviously not have energy consumption. Also use common acronyms like "TV", "CD".
> - Give preference to names used in ordinary language. Avoid brand names.
> - Use commas to distinguish related types of products, e.g. "TV, CRT" and "TV, LCD" or "Clothes dryer, electric" and "Clothes dryer, gas". Related types need not be in the same category.
> - Use "/" within lists rather than commas. Use only one comma; if more needed use parentheses and "/"s).
> - Use parentheses to denote product types that share a common name, e.g. "Amplifier (network)" and "Amplifier (audio)".
> - Distinguish between products that can be run off of integral rechargeable batteries ("rechargeable products") from those that cannot ("non-rechargeable products"). Non-rechargeable products includes both those that can be run from AC or generic batteries and those that can only be powered by AC (e.g. some audio minisystems); this distinction is not considered significant for the purposes of the taxonomy. It is not considered significant whether a battery powerable product can be used while being AC powered (e.g. many shavers, mobile phones) from those that can't (e.g. power tools, some vacuums).
> - "Portable" as a suffix to indicate if something can be easily moved, not whether it can be powered by batteries.

While this taxonomy was developed specifically for use by energy researchers, these principles seem sound, with the possible exception of the use of commas. For the UCD, changing "Water dispenser, bottled" to "Bottled water dispenser" might be preferable.

Description

Each entry should also have a one sentence description of it, in order to broadly outline what is covered; the "comment" in the UDC table in section 4. The text accompanying the UDC can be the basis of such a description. Some product types may eventually require more detailed clarification.

Languages

English will be the original version of the name and comments about entries in the enumeration, but the standard needs to be translated into all major languages. This is more important for this standard than for most since many people of all sorts will use the information it contains.

Level of detail

As the number of entries in the list grows, it is necessary to have the naming be increasingly specific. In addition, there can be entries that distinguish a device by its application, when that is fixed. For example, many devices include a motor, so that "motor" could be a listed device type. On the other hand, there could also be "fan" or "pump," which are both simply motors with a specialized purpose and attachment to the motor. If a device purchased as a motor ends up being used for pumping, the device remains a motor since the device type is static.

Grouping product types can often be an arbitrary[9] choice. There is no simple algorithm to apply to determine the "right" level of disaggregation. There are multiple reasons to want to have more or less detail. Among these are:

Amount of energy at stake. Since tracking energy use is a key application of the classification, then approximately 100 types should result in each using about 1% of energy use (or electricity use since most devices use no other fuels). Some products will end up using significantly more than 1% and some considerably less, but as the aggregate use drops, it becomes more difficult to justify disaggregation.

Devices per building and fuel type. For devices such as major appliances or water heaters, there is usually just one per residence, so there is little value in distinguishing within these categories, e.g. between horizontal axis and vertical axis clothes washers. Similarly, few buildings have multiple space or water heating systems with different fuel types so it is not necessary to distinguish an electric water heater from a gas water heater (and the difference will be readily apparent in how much electricity is used, and the absence of gas use).

Technology change. Some product types, such as major appliances, have not changed in concept for many decades and seem likely to remain stable into the future. Others, particularly electronics, have evolved significantly over spans of a decade or less. To reduce the rate at which list categories become obsolete, significant specificity should be avoided. One example is media sources for audio and video. Putting particular technologies such as long-playing

[9] An example of how arbitrary some groupings can be, the documentation for the IFC ("7.4.2.7 IfcElectricApplianceTypeEnum") notes:

> IFC4 CHANGE ELECTRICHEATER changed to FREESTANDINGELECTRICHEATER and noted as being for occasional use. RADIANTHEATER removed as part of general 'heater consolidation'. WATERHEATER, DIRECTWATERHEATER and INDIRECTWATERHEATER rationalized to FREESTANDINGWATERHEATER. WATERCOOLER changed to FREESTANDINGWATERCOOLER. COMPUTER, FACSIMILE (FAX), PRINTER, SCANNER, TELEPHONE, TV (TELEVISION) moved to IfcAudioVisualApplianceTypeEnum and IfcCommunicationsApplianceTypeEnum. KITCHENMACHINE added.

records, cassette tapes, VHS tapes, etc. into the taxonomy would render those entries obsolete relatively quickly (for a classification intended to last many decades). Similarly, distinctions between different television display technologies (e.g. CRT vs. LCD vs. Plasma) also are problematic. Another likely example is network equipment; the future combinations of modems, switches, routers, and wireless network equipment are difficult to predict and keeping them all in one category avoids such problems.

Product size. Many products come in wide ranges of capacities in space, speed, or other performance indicator. For example, some printers take many seconds to print each image where others can print over 100 images per second. In this case, there is a continuum of products, and a sharp division between large and small would be necessarily arbitrary. In other cases, e.g. food equipment, the differences are more clear (see building type distinctions below).

Intended building type. Some devices are marketed for personal (household) use or for commercial scale operations, such as food handling (e.g. refrigerators and cooking equipment). Often these correspond to the size of the device, but in other cases the distinction is more to the intended usage pattern (clothes washers and dryers in commercial settings get an order of magnitude more use than household models and need to be considerably more rugged). It is possible to use household/commercial in distinguishing classifications, but as the building type will generally show which type of device is in use, this complication seems unnecessary.

Fraction of buildings that have this device at all. Some devices may use a large amount of energy in total, but be present in only a tiny fraction of buildings, such as particular types of industrial equipment (e.g. blast furnace, metal stamper, etc.). In those where it is present, it is likely to be a dominant consumer. Thus, it seems unnecessary to include specific categories for such devices, and instead group them all as “Industrial Process Equipment” or some such very broad term.

Uses beyond Energy Reporting. Device classification can also serve other purposes. For example, inventories of devices in a building can be automatically created; this can particularly leverage protocols that report brand, model, and serial number data. Mechanisms which facilitate storing of arbitrary local data on the device can place a corporate inventory ID into this for retrieval by an inventorying process. As with Energy Reporting, this is an application where the interaction with a device (obtaining inventory data) is unrelated to the functional purpose of the device. Another example beyond Energy Reporting is for devices to recognize local neighbors and initiate some new functionality based on this. For example, presence of a mobile phone in a room may indicate to other devices that a person is present. Or, a light might learn that a projector screen is near to it, and then turn off when the projector is on. Enabling such additional usages of classification is not a specific goal of this effort, but there is no reason to discourage such uses. The key point is that the process of creating the list need not be encumbered by considering how it may be useful for other purposes.

Products with multiple functions

Some devices have more than one major function (e.g. a combination television and DVD player). As the UDC is intended to be simple, only one device type is allowed, so the manufacturer needs to decide which function is primary. In the TV/DVD example, it would be a TV. When copying/imaging went digital, a new category of product called “multi-function device” was invented to deal with this, though all such devices are covered by “imaging equipment”.

4. Initial Proposal for the Simple Universal Device Classification System (UDC)

In the introduction, we proposed a Minimal list of 36 devices. Here we propose a more substantial enumeration of device types, which we call the Basic list, with 92 entries. As with the Minimal list, the categories are for convenience only.

Category and Device	**Comment**
Space Conditioning (11)	
Unitary System	window and wall units without external components; self-contained
Boiler	device that heats water (or other liquid).
Furnace	device that heats air (or other gas)
Pump	device that moves water (or other liquid)
Fan	device that moves air (or other gas)
Condensing Unit	always includes a compressor
Condensor	no compressor; just fan
Humidifier	adds moisture to air
Dehumidifier	removes moisture from air
HVAC - control	directs operation of other HVAC devices; includes HVAC sensors
HVAC - other	not readily classified into any of the above
Lighting (5)	
Lighting - outdoor	
Lighting - fixed	hardwired
Lighting - portable	has normal plug
Lighting - controls	incl. sensors for lighting
Lighting - other	not readily classified into any of the above
Appliance (10)	large devices; small in misc.
Clothes dryer	
Clothes washer	incl. combined washer/dryer
Dishwasher	
Freezer	
Ice machine	
Oven	incl. warming drawer
Range	incl. cooktop and combined cooktop/oven
Refrigerator	including wine coolers, fridge/freezer combo
Water heater	
Appliance - other	not readily classified into any of the above
Electronics (21)	
Audio system	integrated source and speaker; incl. radio, boombox
Audio/video player	e.g. CD, DVD, VCR, cassette, turntable

Camera	
Computer, desktop	incl. integrated
Computer, notebook	
Computer, server	
Computer, other	
Data storage	
Display	incl. monitor, projectors, TVs, digital picture frame
Electronics - portable	can be operated by battery and not otherwise classified
Game console	
Imaging equipment	fax, multi-function device, scanner, printer, label printer
Musical instrument	also incl. recording devices, mixers, amplifiers
Network equipment	modems, switches, routers, access points, etc.
Phone handset	incl. tablet
Receiver	incl. amplifier, home theatre system
Set-top box	cable, satellite, Internet
Telephony	base stations, answering machines, corded phones
Television	
Audio/video - other	
Electronics - other	not readily classified into any of the above, incl. clocks

Miscellaneous (29)

Agriculture	incl. irrigation timers
Air compressors	
Bathroom device	toilets, faucets, hand dryers, etc.
Battery charger	
Business equipment	money or office paper related
Cleaning equipment	incl. vacuum
Cooking - portable	
Decorations/hobby/leisure	fountains, aquaria, kilns, baby rockers, massage chairs
Entertainment	gambling, arcade, etc.
Exercise machine	
Food service/prep	ice cream machine, fryer, steam cooker
Household	non-food; incld iron, sewing machine, …
HVAC - portable	humidifiers, portable fans, heaters
Industrial	process equipment and related
Kitchen	small devices
Laboratory equipment	
Lighting - decorative	
Lighting - emergency	incl. exit lights
Medical equipment	for professional settings
Microwave oven	
Outdoor appliance	mowers, trimmers, snow melting coils, grill
Personal - health	hair dryers, curlers, shavers, trimmers, toothbrush
Pool - spa	

Sanitation	garbage disposal, trash compactor, wastewater pump, water filter
Sign	not incl. electronic displays
Tool - construction	
Tool - non-construction	e.g. auto, beauty
Vending machine	
Water dispenser	
Infrastructure (11)	Devices not used directly by people
Breakers	incl. AFI/GFCI
Doors / Windows	incl. garage doors, gates, window shades
Fireplace	
Motor	actuators
Power - portable	power strips, surge protectors, UPS, timer
Power - fixed	transformers, switchgears, inverters, voltage regulators, power conditioners
Pump	
Security	security cameras, systems
Sensors	incl. detectors: fire, smoke, gas, fluids
Signage	
Meter	utility and other
Transportation (4)	
Transport, fixed	elevator, escalator, lifts, etc.
Vehicle-large	
Vehicle-small	incl. wheelchair, golf cart
Transport, other	incl. auto engine heater, vehicle charger, parking meter, parking equipment
Other (1)	
Other	truly unclassifiable

5. Next Steps

This proposal needs further review by collaborators, stakeholders, and other interested parties to refine the concept and proposed list. At that point it can be distributed more widely. There will no doubt be people with strong opinions for or against particular aspects; complete consensus is almost never attainable in such circumstances. The key is to get a critical mass of recognition of the problem and that a UDC will be highly useful.

This version of the UDC reflects a U.S-centric view of devices. It needs significant review in comment by people from other regions of the world. It is possible that this might result in a few additions to the list, as well as changes or clarifications to the comments. In addition, some changes to terminology might ease international acceptance or reduce confusion. For example, while in the U.S. the term “appliance” most commonly is used to refer to only large kitchen and laundry “white goods”, in some countries, it is routinely used to refer to many types of end-use devices including electronics and miscellaneous devices.

While the list presented here is in English, most people in the world speak other languages. There should be a freely available repository with standard names and definitions translated into all human languages. Where this should reside, and what process should create those translations, needs to be determined.

After significant informal review, the enumeration should then be brought to a standards organization for addition to an existing standard, or creation of a new standard should be created. The UDC should ultimately be, or be part of, an international standard. Most international standards processes are complex, and this is not likely an ideal (or even possible) first step. It would be much easier to initiate the standard in the context of a U.S.-based standards organization. At some later time, it could be adopted by an international organization. There are exceptions to this principle. IEEE (Institute of Electrical and Electronics Engineers, ieee.org) is substantially a U.S. organization but is officially international. The IETF (Internet Engineering Task Force, ietf.org) is international but as its membership is individual (actually, it has no members at all, but participation is by individuals), then the usual barriers to participation in international standards are absent.

The 2011 classification proposal to the IETF was for a registry for the enumeration of device types (Nordman, 2011b). A sibling organization of the IETF, IANA (Internet Assigned Numbers Authority, iana.org) maintains a variety of lists, including enumerations much like the UDC, but on other topic areas. The most closely related example may be one for location (building) types (IETF, 2006). IANA has an advantage in that it is not tied to any particular product segment (aside from being tied to network equipment), building type, or country, and is clearly global in scope, which could streamline the standards-making process. IANA also has a variety of standard mechanisms available for maintaining and updating such lists and almost certainly one of those would be acceptable for device classification.

Expected Usage

The goal for a UDC is to enable energy management, in the context of energy reporting. A management system for energy in a building will gather up data about all devices in a building — or at least all devices that can report on themselves or be reported on by a second device. For many of these, the management system may have no functional relationship to the device; for example, the system may manage climate control systems directly, but also collect data on PCs and printers with whom it does not otherwise communicate. The energy information collected is generic to any device type; the data are unrelated to the functional services that the device provides. The UDC type may be the only data that the management system has about the device other than its identity on the network. Many buildings are partly or entirely unmanaged, with some devices that consume energy asynchronously.

With UDC data, the management system can readily and automatically provide a breakdown of energy use by major category of device, and by individual device type as warranted. A convenient side benefit of this is that equipment inventories are automatically generated, which can be useful for reasons unrelated to energy use. The system can track energy use by category or type over time, and raise alerts when there is a significant unexpected change in consumption.

Additional Data

Beyond the basic class of a device, additional generic data for every device would be useful. The manufacturer's brand name and model number[10] (text strings of some modest length) can be used in reports, or to help gather additional information about a device. A human-readable name is often associated with such information. Some conventions are needed to encode these in a standard manner.

Manufacturers increasingly create a web page for information about each model they sell. It would be helpful if each device could report a URL for such a page. Additionally, the page could have both human-readable and machine-readable portions, with the latter being encoded in some standard format. This would enable useful information about devices to be gathered automatically by a management system.

These are not the only types of data useful to provide in the context of Energy Reporting, but are the two most tied to product manufacture, where classification will be set.

[10] Some companies have implemented information systems to describe devices. An example is the Cisco Products MIB, in which a device reports its model number. This is an enumeration, starting at 1, and each entry corresponds to a specific model number (over 1,300 as of 2013).
This is not an enumeration of device types, but rather of model numbers.
http://tools.cisco.com/Support/SNMP/do/BrowseMIB.do?local=en&mibName=CISCO-PRODUCTS-MIB

Related topics

There are many standards that speak to identity on a network, or service discovery. These are distinct from basic classification. Device classification is comparable to the first impression a human being might have about a device, recognizing its core function or type.
Identity on a network can be something like that provided by domain name systems (e.g. "www.whitehouse.gov"), or an IP or MAC address (128.12.13.212 or d5:ad:b0:2e:16:b6). These can be thought of as **who** an entity is, not **what** it is. Service discovery is the process by which one entity on a network determines what functions can be provided by other entities on the network. A service for an imaging device could be printing, scanning, faxing, or copying; these are things a device can **do**, not what it **is**. Classification is distinct from both identity and service discovery.

Some companies have implemented information systems to describe devices. An example is the Cisco Products MIB, in which a device reports its model number. This is an enumeration, starting at 1, and each entry corresponds to a specific model number (over 1,300 as of 2013). This is not an enumeration of device types, but rather of model numbers.
http://tools.cisco.com/Support/SNMP/do/BrowseMIB.do?local=en&mibName=CISCO-PRODUCTS-MIB

Conclusions

A Simple Universal Device Classification System (UDC) is critically needed to streamline and fully exploit the energy management of networked products. Creating such a system need not be difficult, and instituting a reasonably good system sooner is better than waiting for an "ideal" system to be developed. The classification proposed in this report shows that such a system is possible, and can serve as a starting point for a standards process. Manufacturers could even begin to use this list but should specifically identify it as the LBNL-UDC or the UDC-2013 enumeration to distinguish it from a future system that is endorsed by a standards body. Further work should be conducted to subject this list to further review and revision, and then bring it to a suitable standards organization.

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